Instructions

QUINNIPIAC RIVER FUND GRANT AWARD - FINAL REPORT QUESTIONS

This form is to be completed by all nonprofit organizations that received a grant through the Quinnipiac River Fund.

Grant Details

Grant Details

Organization Name
Yale University

Grant Description
to support the study of microplastics and macroplastics in the Quinnipiac River and its source waters.

Total Grant Amount
20,000.00

Report Questions

1. List the specific objectives/outcomes of the project and tell how they were met during the grant period. Also, provide an update on any special conditions of the grant (if applicable).

Macroplastics and microplastics (MPs) have emerged as a ubiquitous contaminant class with probable human health impacts. They are ubiquitous, and MPs have been found in every corner of the earth's environment, from polar ice to deep ocean basins, though they are more abundant closer to anthropogenic sources. MPs are mainly derived from break down of macroplastics, and they carry organic compounds that are added as part of the plastic formulation (like BPAs) as well as metals and toxic organics unintentionally adsorbed to their abundant surfaces. MPs have been found in many foods, as well as drinking water.

The global cycle and mass balance of these contaminants is poorly understood, and one source that remains especially uncertain is storm run-off. Stormwater in urban areas picks up litter, including especially plastics, and carries it untreated to receiving water bodies like streams and lakes and eventually the ocean. The few studies that have examined this question estimate that terrestrial sources are the main supplier of plastics to the ocean. The two greatest of these sources are (1) sewage treatment plants (STPs; Okoffo et al., 2019), and (2) macroplastic litter that breaks down physically into smaller pieces and enters the MP size range (Fig. 2) (Silva et al., 2018). The current study supports the idea that storm runoff is more important than treated sewage as a source. As just on example, we have been able to calculate that a single plastic bottle can transform into several billion MP particles in the urban environment. Because they are a new contaminant class and because their impact on human health is uncertain, MPs are almost entirely unregulated so far.

In the current research we sought to measure macroplastics and MPs for a representative urban subwatershed of the Quinnipiac River. This research built on prior related investigations and recently helped to win funding from NOAA to study macroscopic plastic litter. In combination, these analyses can have the immediate practical utility of assessing macroplastic and MP levels in source waters typical of the Quinnipiac River. This information can help watershed managers to take actions to limit macroplastic and MP release and human exposure to these potentially toxic substance classes. Our work is adding to the sparse record of plastics in urban storm run-off, which has only rarely been measured. Because of COVID constraints we refocused our efforts on a single representative catchment. No single river can represent conditions in the entire world, but the Quinnipiac is certainly typical of circumstances prevailing in much of North America.

Sample Collection, Preparation, and Analytical Methods

A key part of this project was developing reliable methods for measuring both macroplastics and MPs. Particles larger than the MP range (> 5 mm) were screened out of water samples by passing through a #4 mesh filter (5200 μm). For storm drains, time series samples were collected during rain events to characterize changes in MP levels over time to provide an accurate quantitative assessment. We have found that there was a first flush effect, with greater concentrations occurring early in storms. This has been demonstrated for many substances, but MPs had never previously been tested. Sample timing was optimized to collect about 10 samples in a given storm (sampling interval from 10 – 30 min). Up to ten 2 liter samples can be collected in this way with our ISCO Model 3700 autosamplers.

MPs in filtered material were separated from natural biogenic organic matter (like leaves) by treatment with 30% hydrogen peroxide (H_2O_2) with Fe catalyst and 10% KOH (wt/vol) at 50 °C for 1 h. Fe was added as 0.05 M Fe(II) 1:1 (vol/vol) to the H_2O_2 + KOH solution. This approach has been shown to be rapid and effective for all natural organic matter, while not significantly altering synthetic MPs (Prata et al., 2019). Following chemical treatment, MPs were further isolated by density floatation in concentrated NaCl to remove dense grit (like sand). Floated MPs were rinsed with distilled water, filtered, dried, and weighed. Identification was carried out optically with a stereomicroscope. Previously we confirmed identification on some samples spectroscopically by Fourier transform infrared spectroscopy (FTIR) or Raman spectroscopy. In the current project, the simpler Nile Red method was used. Plastics stained with this dye turn fluorescent red. Sample volumes were adjusted (1) to ensure that adequate numbers of MPs were collected for measurement by these techniques, and (2) to safeguard against excessive amounts of solid material that could saturate the screens and filters, leading to measurement artifacts.

Anthropogenic litter macroplastics were characterized with a 20-category typology we devised. Macroplastic samples were sorted and then weighed on an analytical balance. We paid special attention to plastic fragments, pieces we define as comprising less than half of the weight of the original item. These reflect plastic in the process of being transformed from anthropogenic litter to MPs.

Because of limitations imposed by the early stages of the COVID pandemic, we were not able to achieve all of the original goals of the proposed research. Nevertheless, the current research identified and quantified 20 categories of trash carried by storm drains and deposited in waterways. Plastic bottles of various sizes account for as much as 80% of AL. We also found that larger anthropogenic plastic litter quickly breaks down to smaller pieces; presumably, eventually becoming MP (size range below 5 mm). This research supports the belief that conversion of macroplastics from land to MPs carried by rivers like the Quinnipiac is the major source to the world's oceans.

2. Please share your successes, challenges and any lessons learned through the implementation of your project. Were there any unintended consequences or lessons learned that may affect how you operate your program moving forward?

As documented in our mid-year progress report, we successfully established detailed methods for analysis of microplastics. We also collected a detailed time series of samples from a typical storm drain outfall. This also included measurement of the key background water quality parameters turbidity (cloudiness), suspended particulate matter (SPM), and salt, which we showed correlate with MPs. In so doing, we used state of the art clean techniques during sampling and sample processing to ensure measurements were not artificially elevated by field or laboratory contamination artifacts. However, in the end we were unable to sample broadly across Quinnipiac River tributaries as we had hoped.

This shortfall was occasioned entirely by COVID-19 restrictions. Almost immediately after we received funding, Yale labs and field research were shut down because of the pandemic. It took many months for Yale to again allow use of labs, and then only following strict safety protocols that hindered research productivity. A similar but somewhat less crucial issue was a delay in accessing the FTIR instrument that eventually allowed positive identification of specific plastic types.

Although the hindrances imposed by COVID-19 were quite substantial, they were unique to this historic global event and will not affect how we operate our program moving forward.

3. What are the opportunities and needs of your organization as it continues to move forward with its work to positively impact the Quinnipiac River?

There are numerous specific needs and opportunities for working on the Quinnipiac River. The ones we will pursue will depend on specific goals, and the unique challenges we face in our efforts to improve water quality.
Opportunities for working on water quality improvement in the Quinnipiac River:
1. Community Engagement: Engaging with local communities to raise awareness and involve residents in cleanup efforts can foster public support and volunteer involvement.
2. Partnerships: Collaborating with local governments, environmental agencies, non-profits, and businesses can provide access to resources, funding, and expertise.
3. Grants and Funding: Pursue grants and funding opportunities from government agencies, private foundations, and corporate partners to support restoration and research efforts.
4. Technological Advancements: Embracing new technologies and monitoring systems to improve data collection, analysis, and water quality management.
5. Educational Programs: Developing educational initiatives to inform the public about water quality issues, conservation practices, and the importance of the Quinnipiac River ecosystem.
6. Policy Advocacy: Advocating for policy changes that can help protect and improve water quality, including stricter pollution controls and sustainable land use practices.
7. Watershed Management: Implementing comprehensive watershed management plans to address pollution sources and promote sustainable land use within the river's watershed.
Needs for organizations working on water quality improvement in the Quinnipiac River:
1. Scientific Research: Conducting ongoing water quality monitoring and research to understand the river's health and the sources of pollution.
2. Infrastructure Improvement: Investing in infrastructure upgrades to prevent sewage overflows and stormwater pollution.
3. Community Support: Building and maintaining strong relationships with local communities to foster volunteerism and public engagement.
4. Funding: Securing sustainable funding sources to support long-term restoration efforts and ongoing monitoring.
5. Data and Analysis: Developing robust data management and analysis capabilities to track progress and adapt strategies as needed.
6. Regulatory Compliance: Ensuring compliance with water quality regulations and work with regulatory agencies to address violations.
7. Public Awareness: Continuing public outreach and education efforts to build support and awareness of water quality issues in the Quinnipiac River.
8. Ecosystem Restoration: Implementing projects to restore and enhance the river's natural ecosystems, such as wetlands and riparian areas, to improve water quality.
9. Collaboration: Fostering partnerships with other organizations and stakeholders to leverage expertise and resources in achieving common goals.

Attachments

Financial information (required): Please provide a detailed accounting of how the specific grant dollars were spent based on the budget submitted in the grant application.

Detailed Accounting

Plastics and Microplastics final.xlsx

Pictures (optional): Please attach 1 to 3 pictures of activities that have occurred throughout the grant period (with a description for each) as a result of grant funding. All pictures should be submitted in JPEG format and may be uploaded to www.thequinnipiacriver.com and used in Foundation publications.

Picture 1

Alexandra in pipe.jpg

Description

Student at sampling site used for sample collections to measure macro- and microplastics

Picture 2

Microscope stereo.jpg

Description

Stereo-microscope set up in the clean room to avoid contamination artifacts. Computer screen in the background shows a typical filter and its microplastics.

Picture 3

MPs magnified.jpg

Description

Typical microplastics showing a plastic fiber, fragment, and tire wear particle.